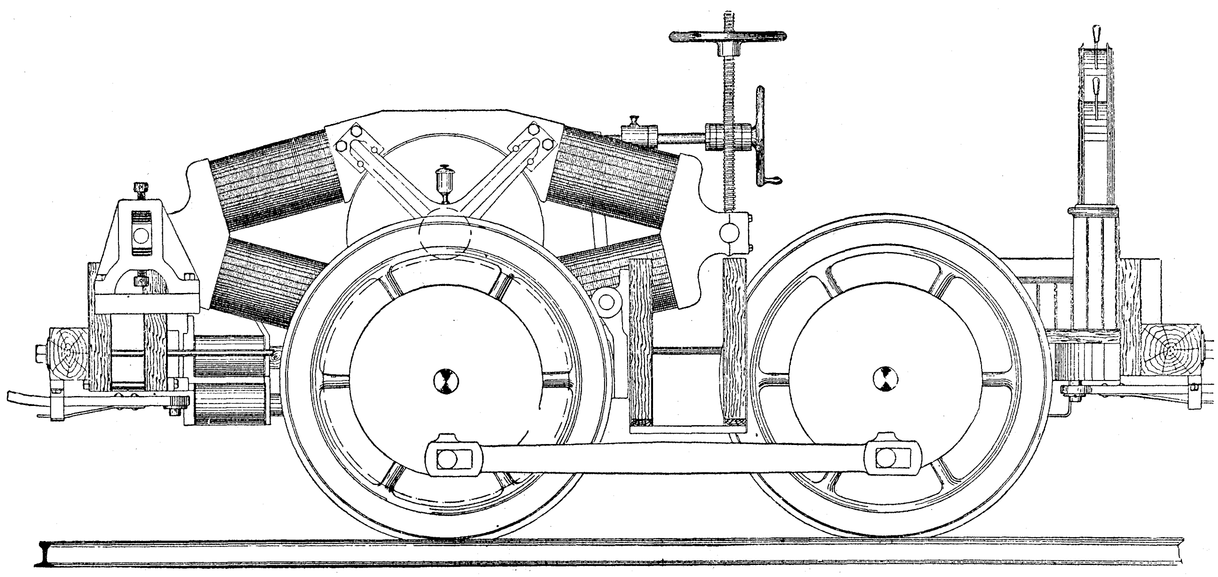
locomotives as the average of all conditions of track as affected by weather and use.

3. The possibility of dispensing with the complicated methods of insulation that are necessary and most expensive features of high-potential systems.

4. A potent cause of the economical working of electric railways is found in the capacity for instantaneous adjustment of the current to demands made upon it. This is so marked in the case of a double-track road with the same number of trains moving in both directions, and all deriving their power from a common generating-station, as to prompt Dr. C. A. Siemens to draw this striking analogy. He declares that two trains on the same track, one descending and the other ascending a gradient, are in as absolute connection by the current in the rails as if tied together by an actual rope. The counter-current generated by the free revolution of the dynamo of the descending train re-enforces the main current, and thus helps the ascending. The result of this is that the maximum capacity of the generating-station need only equal the average work of one motor multiplied by their total number. This will always prove sufficient. Every steam-locomotive must be ready at all times to exert its full power; and the waste of this, in the aggregate, is enormous.



SIDE-ELEVATION OF DAFT ELECTRIC MOTOR 'FRANKLIN.'

The following facts are significant as regards electrical propulsion: 1. The production, by modern stationary engines of the highest efficiency, of a horse-power for two pounds of coal, or less, per hour; 2. A recovery, in kind, from an electric circuit of reasonable length, of at least sixty-five per cent of the mechanical power applied to it; 3. The consumption by small stationary and locomotive engines of from seven to nine pounds of coal per horse-power per hour; 4. The consequent development in the circuit of a horse-power for three pounds of coal as opposed to seven or nine; 5. A marked reduction in original and current cost of motive power, due to lessened weight, simplicity, and diminished attendance; 6. A notably lower rate of deterioration than other machinery, due to the use of low-potential currents, absence of reciprocatory motion, etc.; 7. Conservation of permanent way, arising from the lessened weight of motor due to superior natural adhesion and the power of increasing the same magnetically to any necessary degree; 8. A unique economy arising from the fact that there is no necessity of having superfluous power in reserve, — a consequence of the capacity for instantaneous adjustment of a current throughout an entire circuit to the demands made upon it.

If one may judge by comparison with other mechanisms, the future of the dynamo-electric motor is pregnant with possibilities. The measure of perfection of any machine is the degree of efficiency with which it performs its specific work. Referred to such a criterion, dynamo-electric machinery stands, at the very starting-post of its career, infinitely nearer to its theoretical ultimate than the familiar steam-engine, which has profited by eighty years of use, experiment, and analysis by the best human ingenuity.

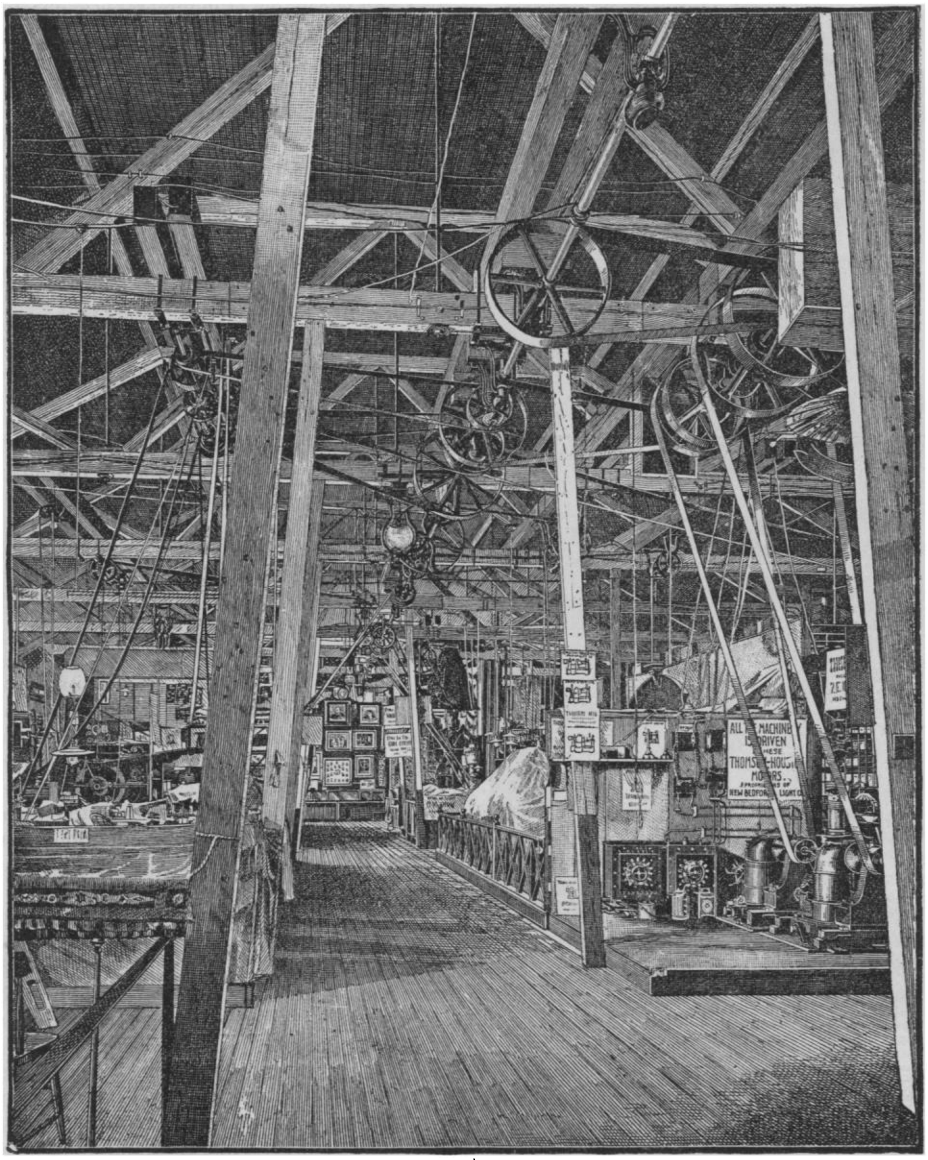
To resort to generalization, the steam-engine's characteristic function is to transform heat into mechanical work; and the labor and thought of three generations have only succeeded in recovering, in the shape of work, from ten to twenty per cent of the total heat applied to it. The peculiar office of the dynamo-electric machine is the conversion of mechanical work into current electricity; and in the first decade of its useful existence it returns, in the form of electrical current, ninety per cent of the mechanical work applied to it. The adept steam-engine attains one-tenth of its possible efficiency; the tyro dynamo-electric machine, nine-tenths. "If they do these things in a green tree, what shall be done in the dry?"

ELECTRICAL POWER-DISTRIBUTION.

ONE of M. Victor Popp's friends was recently describing with post-prandial eloquence the wonderful system of compressed-air distribution now so extensively operated in Paris. As if it were not marvellous enough to picture to his hearers' minds pneumatic clocks throughout Paris, and all sorts of machinery deriving power from a central station for compressing air, the interesting 'diner-out' added with a most graceful gesture, "Why, messieurs, with the Popp system you freeze the dead bodies in the morgue, and you cremate them in Pere la Chaise." And thus the idea is continually forced upon one's mind that this is an age of centralization in the supply of heat, water, light, and power, and, in fine, every thing that makes life more comfortable, and business more practicable. The application of electricity to the distribution of power has been developed with comparatively more marked progress than the electric-lighting industry met with in the early stages of its existence; and this is not strange, when we consider the advantages of electric motors, and the fact that their use makes a material difference with small manufacturers in the item of cost of power, besides constituting an important feature of safety. The fact that the noisy, dusty, and dangerous steam-engines which are being used in so many printing-offices, book-binderies, and various other shops where power is needed, may be displaced by quiet-running electric motors, which are not dangerous and do not take up much room, added to the actual saving in money which is accomplished by such a change, are points which are so easy of demonstration, and commend themselves so readily to the popular mind, that the introduction of electric motors has not met with any serious obstacles. Although the first experimenters built motors before they built dynamos, it is only within the last two or three years that practical machines of a high efficiency have been offered to the public. Some of the machines now give an efficiency of over ninety per cent in the conversion of electrical into mechanical

energy; and it is plain that there is no possibility of very much improvement in the efficiency of conversion. The regulation of the electric motor is accomplished in some cases by artificial means; but in the most approved type of electric motors the regulation is in the machine itself, and depends upon an electrical principle as interesting and wonderful as any fact in the whole range of the science. Comparatively speaking, it is this. Dynamos and motors are interchangeable: when we put mechanical power to the machine, and make thereby electrical power for further use, we call the apparatus a dynamo-electric machine; if we reverse the process, however, and bring forth mechanical power by putting a current of electricity through a machine, it becomes an electric motor. Every motor, while receiving the electric current and doing mechanical work, is at the same time retaining to some degree its character as a dynamo-machine; for it is generating a current directly in opposition to the current which causes it to run. This opposing current serves as a resistance to the current supplied to the motor, and varies with the speed of the motor.

Now, in the Thomson-Houston motor, which is here illustrated, if the speed has a tendency to slacken, this opposing current necessarily becomes less, and thus admits to the motor more of the supply-current, which, in its turn, brings back the speed of the motor to its normal speed. The working-power of the motor increases as the square of the current, so that a slight increase in the current (due to the momentary slackening of the speed) is sufficient to make the motor take up its increased load. The change in the electrical condition is practically instantaneous, so that no change in the speed of the motor is perceptible within the moderate changes in the work which it is doing. With a maximum change in the load which the motor is carrying, the variation of the speed of the motor is within two per cent of its normal speed. Such close regulation, it is needless to say, is all that can be desired in any machine. The motors of the Thomson-Houston Electric Company, like all the other apparatus of that system, have been widely introduced, and are in use in many printing-offices, machine-shops, and small factories. They are made in sizes to furnish from one-half to seventy-five horse-power. The larger sizes are, of course, especially valuable for the transmission of power from waterfalls whose distance unfits their utilization by the old methods. Factories may be placed some distance from the water-supply, and get power over the wires.



THOMSON-HOUSTON MOTORS IN THE BOARD OF TRADE EXHIBITION, NEW BEDFORD, MASS.

In addition to the stationary motor, the Thomson-Houston Company have developed extensively those applicable to electric street-cars, having in operation twenty-three electric roads, and eleven in process of construction.

The accompanying illustration represents two Thomson-Houston motors in the exhibition of the Board of Trade at New Bedford, Mass. These motors are supplied by current from the central electric-lighting station of the New Bedford Gas Company, and are furnishing to the shafting all the power required in the various exhibits at this fair.